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In re Patent Application of: Gregory M. Chrysler et al.
Title: FOLDED FIN HEAT SINKS
Attorney Docket No.: 884.148US1

PATENT APPLICATION TRANSMITTAL

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UNITED STATES PATENT APPLICATION

FOLDED FIN HEAT SINKS

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FOLDED FIN HEAT SINKS

Technical Field

The present invention relates generally to heat sink devices. More particularly, the invention pertains to folded fin heat sinks.

Background Information

Crucial to the relentless progress of information technology is the ability to control a by-product of technology called heat. Given the historical rate of doubling the processing and delivering of information every 18 months, more electrons are being moved about in tighter space and at faster speed. As a result, the heat dissipation requirement has risen proportionally to the advances in information technology. Prior innovations like the extruded heat sink, the die-cast heat sink, and standard fin heat sink have attempted to alleviate the problem, but they all have been unable to accommodate certain requirements of modern systems.

Not one of the above-mentioned heat sinks has the required thermal dissipation rate while accommodating the decrease in the structural geometry of modern devices. The extruded fin heat sink and standard fin heat sink have a similar thermal dissipation capability to each other, but such capability cannot be increased unless a larger size heat sink is used. The die-cast heat sink has an inferior dissipation capability because the manufacturing of these die-cast heat sinks is dependent on the materials that can be used in the molding process. These materials have a poor thermal dissipation capability. Both extruded and die-cast fin heat sinks have less than adequate aspect ratios. The aspect ratio is understood to mean the ratio of fin height to fin thickness. Extruded and die-cast fin heat sinks can boast only a 10:1 ratio, yet the aspect ratio required for dissipating the amount of thermal energy generated in modern devices may be greater. The standard fin heat sink seems to be constrained in its ability to expose only some of its surfaces to the

convection medium. So, it too does not provide the dissipation needed by modern devices.

Thus, what is needed is a heat sink that inhibits deterioration in the performance of electronic devices due to the presence of heat or thermal energy.

Summary

An illustrative embodiment of the invention describes a heat sink comprising a number of laterally placed planar fins forming from a single sheet. The number of laterally placed planar fins define a folded fin structure. The top of at least one fin of the folded fin structure is modified to form an opening to receive a convection medium. The heat sink also includes a base that is attached to the bottom of the folded fin structure.

Another illustrative embodiment describes a method of manufacturing a heat sink. The method includes creating a number of openings placed at predetermined intervals on a sheet, folding the sheet in an accordion fold to form a number of laterally placed fins, and attaching a base to the bottom of the number of laterally placed fins.

Brief Description of the Drawings

Figure 1 is an exploded isometric view showing a heat sink in accordance with one embodiment of the present invention.

Figure 2 is an assembled isometric view showing a heat sink in accordance with one embodiment of the present invention.

Figure 3 is a front view showing a heat sink in accordance with one embodiment of the present invention.

Figure 4 is a side view showing a heat sink in accordance with one embodiment of the present invention.

Figure 5 is a cross-sectional view of a heat sink in accordance with one

embodiment of the present invention.

Figure 6 is a view of the flow of the convection medium of a heat sink in accordance with one embodiment of the present invention.

Figure 7 is a close-up view of a base of a heat sink in accordance with one embodiment of the present invention.

Figure 8 is a front view showing a heat sink in accordance with one embodiment of the present invention.

Figure 9 is a close-up view of a bend of the fins of a heat sink in accordance with one embodiment of the present invention.

Figure 10 is a view of a flat stock metal sheet according to one embodiment of the present invention.

Detailed Description

In the following detailed description of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown, by way of illustration, specific embodiments in which the invention may be practiced. In the drawings, like numerals describe substantially similar components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the present invention.

Figure 1 is an exploded isometric view showing a heat sink 100 in accordance with one embodiment of the present invention. The heat sink includes fins 110. The fins allow an increase in surface area for thermal dissipation without increasing the overall volume taken by the heat sink.

Increasing surface area for a given volume is important in heat sinks. This is because the rate at which the heat sink can cool a device having thermal energy is proportional to the surface area of the heat sink. Thus, dissipation rate is dependent

on space in this relationship; hence, to increase the rate of cooling requires an increase in the area from which cooling can take place. Modern electronic devices have high thermal dissipation requirements, but these devices also have decreasing footprints.

Returning to Figure 1, the fins are formed from a flat stock metal sheet. The sheet is made out of materials that are thermally conductive. In one embodiment the material is a thermally conductive plastic. In another embodiment, the stock sheet is made out of copper. In another embodiment, the stock sheet is made out of aluminum. In another embodiment, the fins are made from a compound containing copper. In a further embodiment, the fins are made from a compound containing aluminum.

The fins have a first set of bends 112 and a second set of bends 114. The set of bends 112 is modified to have a set of openings 116. In one embodiment, the set of openings 116 is created after the fins have been formed from the flat stock metal sheet. In another embodiment, the set of openings 116 is created on the flat stock metal sheet prior to forming the fins. The set of openings 116 allows a convection medium, such as air, to flow vertically into the fins.

The fins have a number of planar surfaces 118 and a front 117. The set of bends 112 and 114 define the top and bottom of the fins, respectively. The top of the fins is attached to a fan 120, in one embodiment. In another embodiment, the fan is attached to the front of the fins. In a further embodiment, one fan is attached to the top of the fins while another fan is attached to the front of the fins.

The fan introduces a convection medium, such as air, to the heat sink 100. In one embodiment, the convection medium is introduced to each surface of the planar surfaces. In another embodiment, the convection medium is introduced to greater than fifty percent of the planar surfaces.

The bottom of the fins is attached to a base 130. Various embodiments of how the fins attach to the base are discussed below. In one embodiment, the base

130 is solid. In another embodiment, the base 130 is a chamber. In another embodiment, the base is made from aluminum. In another embodiment, the base is made from copper. In another embodiment, the base is made from a compound containing aluminum. In yet another embodiment, the base is made from a compound containing copper. In a further embodiment, the base is made from manufactured diamond.

Figure 2 is an assembled isometric view showing the heat sink 100 in accordance with one embodiment of the present invention. The top of the fin structure 110 as defined by the set of bends 112 is attached to a fan 120. In one embodiment, another fan is attached to the front 117. The fan 120 forces a convection medium to flow parallel to the fin structure. The other fan attached to the front 117 forces a convection medium to flow parallel to the base 130. However, in another embodiment, the fan 120 attaching to the top of the fin structure is sufficient to guide the convection medium to flow parallel to the fins as well as parallel to the base. These two parallel flows carry more thermal energy than either one alone.

Aspect ratio is a measurement in thermal management that is indicative of fin height to fin thickness. In other words, it is an efficiency measurement regarding the number of surfaces available for the dissipation of heat against the space taken up by the heat sink device. The heat sink device as described in the above and below embodiments has an aspect ratio between about 20:1 to 30:1.

Figure 3 is a front view showing the heat sink 100 in accordance with one embodiment of the present invention. In one embodiment, the bottom of the fin bundle 110 is bonded to the base 130 through a brazing process. In another embodiment, the bottom of the fin bundle is bonded to the base by application of an epoxy. In another embodiment, the bottom of the fin bundle is bonded to the base by soldering. In a further embodiment, the bottom of the fin bundle is thermally clamped to the base by at least one clip.

Figure 4 is a side view showing the heat sink 100 in accordance with one embodiment of the present invention. The fan 120 introduces a convection medium to flow through the openings 116 to reach the base 130. The convection medium takes up the thermal energy transferred through the base and carries it parallel to and out of the base.

Figure 5 is a cross-sectional view of the heat sink 100 in accordance with one embodiment of the present invention. Figure 5 is a cross-sectional view of Figure 4. A flat stock metal sheet is creased to form fins 110 with an accordion configuration. The top of the fins has a number of bends 112. These bends are trimmed to reveal a number of openings 116. The top of the fins is attached to the fan 120. The bottom of the fins is attached to the base 130.

The surface 534 of the base receives thermal energy generated from electronic components. Electronic components interface with the heat sink through the surface 534 of the base. Thermal energy received at the surface 534 is conducted throughout the base. Subsequently, the thermal energy is presented at surface 532. The fins then conduct the presented thermal energy at surface 532 throughout the number of surfaces 118 of the fins. The thermal energy on the number of surfaces 118 is transferred onto a convection medium 522 flowing parallel to the number of surfaces 518. The convection medium engages the number of surfaces 518 by flowing down each natural opening of the fins as well as the trimmed openings of the fins. The convection medium now carries the transferred energy down toward the base. Once the convection medium engages the base, the convection medium turns about 90 degrees and flows parallel to the base (into and out of the page of Figure 5). As the convection medium turns, it picks up more thermal energy from the base, and carries the thermal energy away into the ambient environment of the heat sink.

The fan is responsible for introducing the convection medium to the fins. The trimmed bends of the fins allow more thermal energy to be exposed to the

convection medium. For illustrative purposes only, the fan introduces another convection medium 524 to the fins. Without the trimming technique of the described embodiments, the convection medium 524 engages only a portion of the number of surfaces 518. Thus, less thermal energy can be transferred to the convection medium 524. In contrast, the convection medium 522 can flow through the natural openings of fins and also through the trimmed openings of the fins. Therefore, with the application of the trimming technique, more thermal energy can be carried away before it diminishes the performance of electronic components.

Figure 6 is a view of the flow of the convection medium of a heat sink in accordance with one embodiment of the present invention. Figure 6 is a front view of the heat sink as presented in isometric form in Figures 2 and 4.

The fan 120 introduces a convection medium 640 into the fins 110. The convection medium 640 flows parallel to the plurality of surfaces of the fins. Once the convection medium 640 engages the base 130, it turns about 90 degrees to seek an exit from the fins and flows parallel to the base. The described flow mechanics of the convection medium 640 turns out to carry a large amount of thermal energy.

The reason the convection medium 640 carries more thermal energy is because the 90 degree turn incidents the convection medium upon a thin boundary layer of thermal energy on the surface of the base. More energy is transferred in such a boundary layer than with a thicker boundary layer.

Figure 7 is a close-up view of the base of the heat sink 100 in accordance with one embodiment of the present invention. The base 730 defines a chamber 740. In one embodiment, the chamber is a vacuum. The chamber is partially filled with a small quantity of aqueous solution 750. In one embodiment, the aqueous solution is water.

Electronic devices interface with the heat sink at the surface 734. At that interface, electronic devices transfer thermal energy to the surface 734. The thermal energy at the surface 734 excites the aqueous solution. Such excitation transforms a

portion of the aqueous solution to a gaseous state 752. Functionally, thermal energy at surface 734 is transferred to the gaseous state 752 when the aqueous solution shifts state from liquid to gas.

The gaseous state 752 rises to the top of the chamber. Here, The gaseous state 752 encounters the cooler surface at the top of the chamber. The gaseous state 752 shifts to liquid state 754 and condenses at the top of the chamber. The thermal energy in the liquid state 754 is transferred to the surface 732. The liquid state 754 then travels back to the bottom of the chamber where it rejoins the aqueous solution.

The thermal energy at the surface 732 is carried away by the convection medium introduced by fan 120 into the fin structure 110.

Figure 8 is a front view showing the heat sink 100 in accordance with one embodiment of the present invention. In one embodiment, the fins are fixedly attached to the base 130 through at least one clip 860_0. In another embodiment, clip 860_1 is used together with clip 860_0 to hold the fins to the surface 132 of base 130. In yet another embodiment, a layer of thermal gel is deposited between the set of bends 114 and the surface 132. Other embodiments may include thermal grease, epoxy, phase-changed material, or thermal interface material. This layer of thermal gel facilitates better transfer of thermal energy away from the base to the fins.

Figure 9 is a close-up view of a bend of the fins of a heat sink in accordance with one embodiment of the present invention. Bend 900 is situated laterally adjacent to other bends 906_0 and 906_1. Bends 900, 906_0 and 906_1 are created from folding a sheet to form the fins of the heat sink. Bend 900 includes an arch 902. Bend 900 also includes supporting walls 905_0 and 905_1.

In one embodiment, the arch is defined by the radius 904_0, 904_1, and 904_2 measuring from the focus 906. The arch is removed to allow a convection medium to enter the space underneath the arch. In another embodiment the arch and a portion of the support walls 905_0 and 905_1 are removed.

Standard fin heat sinks allow the convection medium to flow through the

natural opening between the bends 900 and 906_0, and the bends 900 and 906_1. The present embodiment not only allows the convection medium to flow in the natural openings but also guides the convection medium to flow inside the bend 900 (underneath the arch). By opening up the bend 900, the present embodiment essentially increases the surface area by which thermal energy can be carried away within the same heat sink dimensions.

Figure 10 is a view of a flat stock metal sheet 1000 according to one embodiment of the present invention. This sheet is used to manufacture the fins as described above. The sheet 1000 has a width 1002 and a height 1003. It also has a certain thickness. These dimensions are chosen so as to satisfy two criteria. First, the dimension of the sheet is chosen to accommodate the thermal dissipation requirement of a device. Second, the dimension is chosen so that the heat sink can be compatible with the footprint or height requirements of the device.

The sheet has a number of creases 1006_0, 1006_1, 1006_2, ..., 1006_N. For a given width and height dimension, these creases define a fin pitch dimension. the fin pitch is understood to mean to distance between a centerline of one fin to the centerline of an adjacent fin. In the manufacturing process of the fins, these creases are bent so as to form an accordion fold.

The sheet also has a number of openings 1004_0, 1004_1, 1004_2, ..., 1004_N. These openings are created at predetermined intervals on the sheet. In one embodiment, these openings are rectangular in shape. In another embodiment, these openings are oval in shape. In another embodiment, the openings are created through a progressive or continuous stamping operation before the creases are bent to form the fins. In yet another embodiment, the fins are formed and then an End-mill is used to route the number of openings. In a further embodiment, the fins are formed and then a fly cutter is used to create the openings.

Conclusion

A heat sink has been described that inhibits thermal deterioration in the performance of devices. The embodiments of the heat sink described above dissipate more thermal energy in accordance with the requirements of modern devices. Because the embodiments of the heat sink as described above can accommodate the dual requirements of thermal dissipation and modern structural constraints, the heat sink can be used in diverse devices, such as power systems, mobile applications, and server environments.

Although the specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. It is to be understood that the above description is intended to be illustrative and not restrictive. Combinations of the above embodiments and other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention includes any other applications in which the above structures and fabrication methods are used. Accordingly, the scope of the invention should only be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

What is claimed is:

1. A heat sink, comprising:

a plurality of laterally placed planar fins forming from a sheet, the plurality of laterally placed planar fins defining a folded fin structure having a top, a bottom, and a front, and wherein the top of at least one fin of the folded fin structure is modified to form an opening to receive a convection medium; and

a base attached to the bottom of the folded fin structure.

2. The heat sink of claim 1, further comprising a first fan attached to the top of the folded fin structure to introduce the convection medium.

3. The heat sink of claim 2, further comprising a second fan attached to the front of the folded fin structure to introduce the convection medium.

4. The heat sink of claim 1, further comprising a clip, and wherein the clip thermally couples the folded fin structure to the base.

5. The heat sink of claim 1, wherein the sheet is made from a material selected from a group consisting of copper, aluminum, a compound containing copper, a compound containing aluminum, or thermally conductive plastic.

6. The heat sink of claim 1, wherein the folded fin structure allows greater than fifty percent of the plurality of laterally placed planar fins to be receptive to the convection medium.

7. The heat sink of claim 1, wherein the convection medium is guided by the folded fin structure to flow parallel to each surface of each fin of the plurality of laterally placed planar fins and parallel to the base.

8. The heat sink of claim 1, wherein the base is solid.

9. The heat sink of claim 8, wherein the base is made from a material selected from a group consisting of copper, aluminum, a compound containing copper, a compound containing aluminum, or manufactured diamond.

10. The heat sink of claim 1, wherein the base comprises two rectangular faces and four sides to define a sealed chamber.

11. The heat sink of claim 10, wherein the sealed chamber comprises a predetermined quantity of aqueous solution.

12. The heat sink of claim 11, wherein the aqueous solution is capable of

changing to a gaseous state to transfer thermal energy from the second planar face to the first planar face.

13. A method of manufacturing a heat sink, comprising:

creating a plurality of openings placed at predetermined intervals on a sheet;

folding the sheet in an accordion fold to form a plurality of laterally placed fins, the plurality of laterally placed fins defining a folded fin structure having a top and a bottom; and

attaching a base to the bottom of the folded fin structure.

14. The method of claim 13, further comprising attaching a fan to the top of the folded fin structure.

15. The method of claim 13, wherein creating a plurality of openings occurs before folding a sheet in an accordion fold.

16. The method of claim 15, wherein creating the plurality of openings is executed through a progressive stamping process.

17. The method of claim 15, wherein creating the plurality of openings is executed by removing a plurality of rectangular portions at the predetermined

intervals on the sheet.

18. The method of claim 13, wherein creating a plurality of openings occurs after folding a sheet in an accordion fold.

19. The method of claim 13, wherein attaching the base to the bottom of the folded fin structure is executed through using a brazing process.

20. The method of claim 13, wherein attaching the base to the bottom of the folded fin structure is executed through using an epoxy.

21. The method of claim 13, wherein attaching the base to the bottom of the folded fin structure is executed through a soldering process.

22. A heat sink, comprising:

a thermally conductive sheet creased in an accordion fold to form a plurality of surfaces defining a fin bundle having a top and a bottom, wherein the top of the fin bundle is modified to create a plurality of openings, and wherein more than fifty percent of the plurality of surfaces are receptive to an introduced convection medium;

a fan for introducing the convection medium, the fan attached to the top of

the fin bundle; and

a base attached to the bottom of the fin bundle.

23. The apparatus of claim 22, wherein the sheet is made from an alloy containing aluminum.

24. The apparatus of claim 22, wherein the base is made out of manufactured diamond.

FOLDED FIN HEAT SINKS

Abstract of the Disclosure

Folded fin heat sinks are provided to inhibit thermal deterioration in the performance of devices. An exemplary heat sink includes a sheet creased in an accordion fold to form a plurality of fins. The plurality of fins is modified to form a plurality of openings. An exemplary method includes forming the fin from a sheet that has been modified to form a plurality of openings. Given the openings, over fifty percent of the fin structure is receptive to an introduced convection medium.

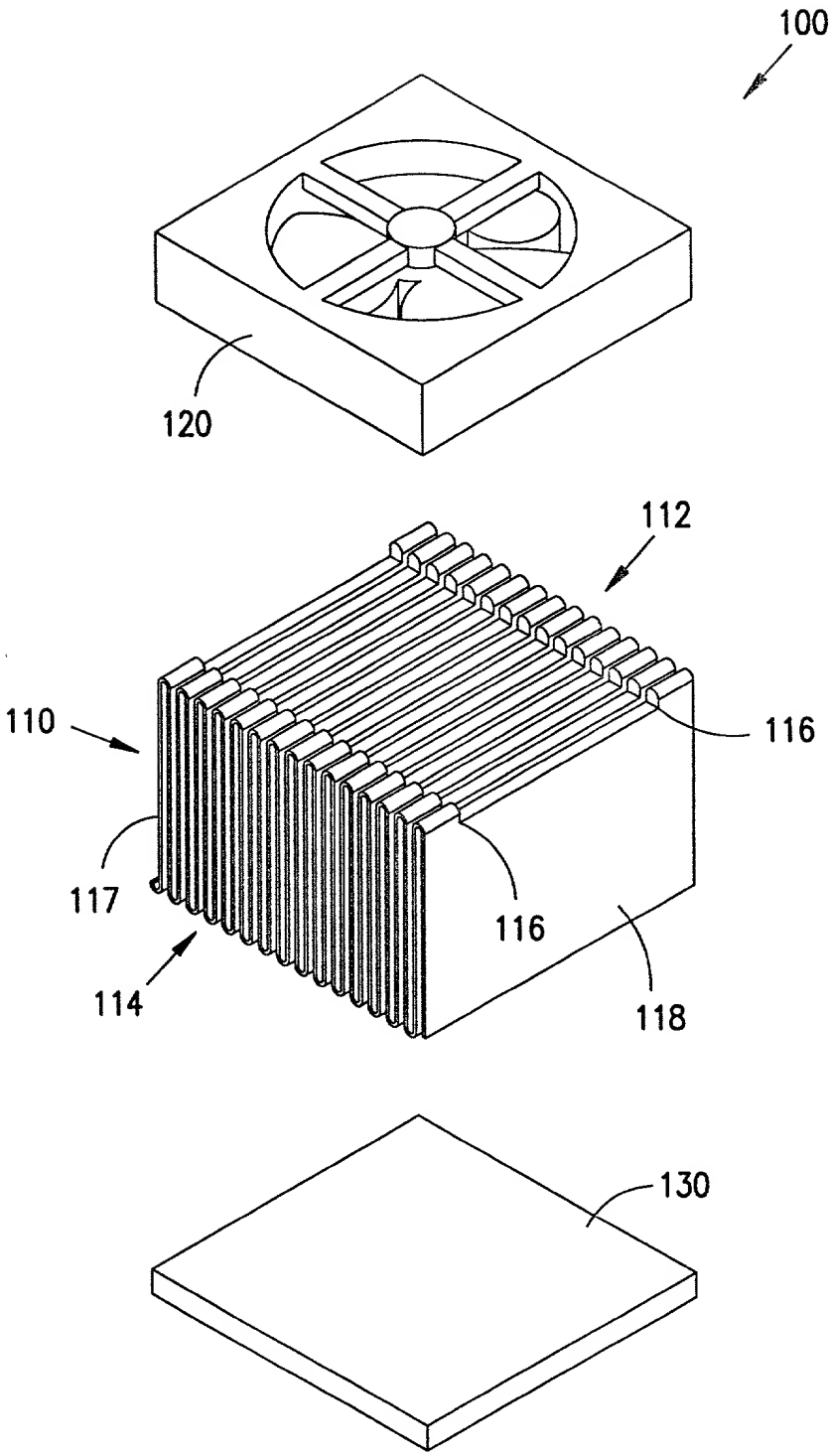

FIG. 1

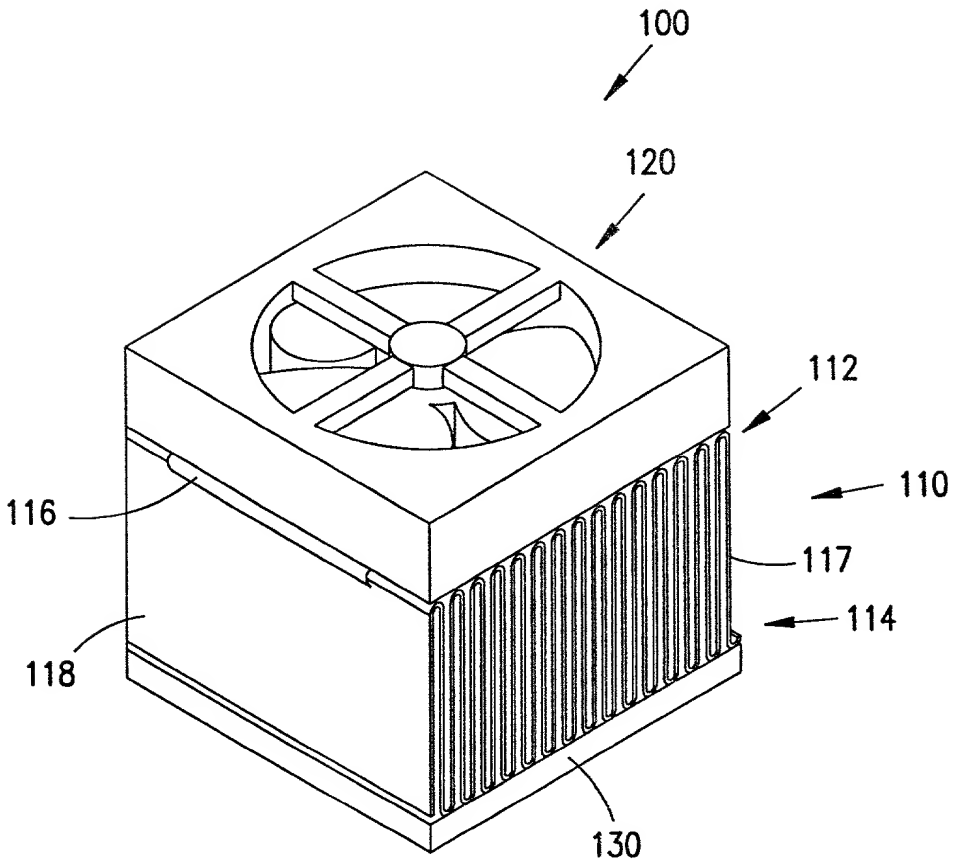

FIG. 2

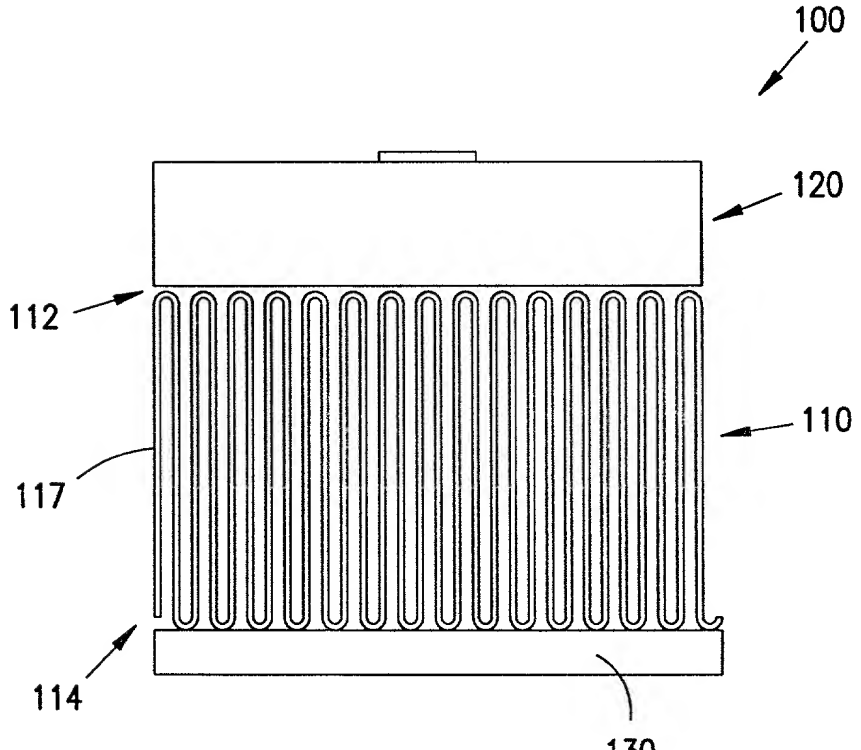

FIG. 3

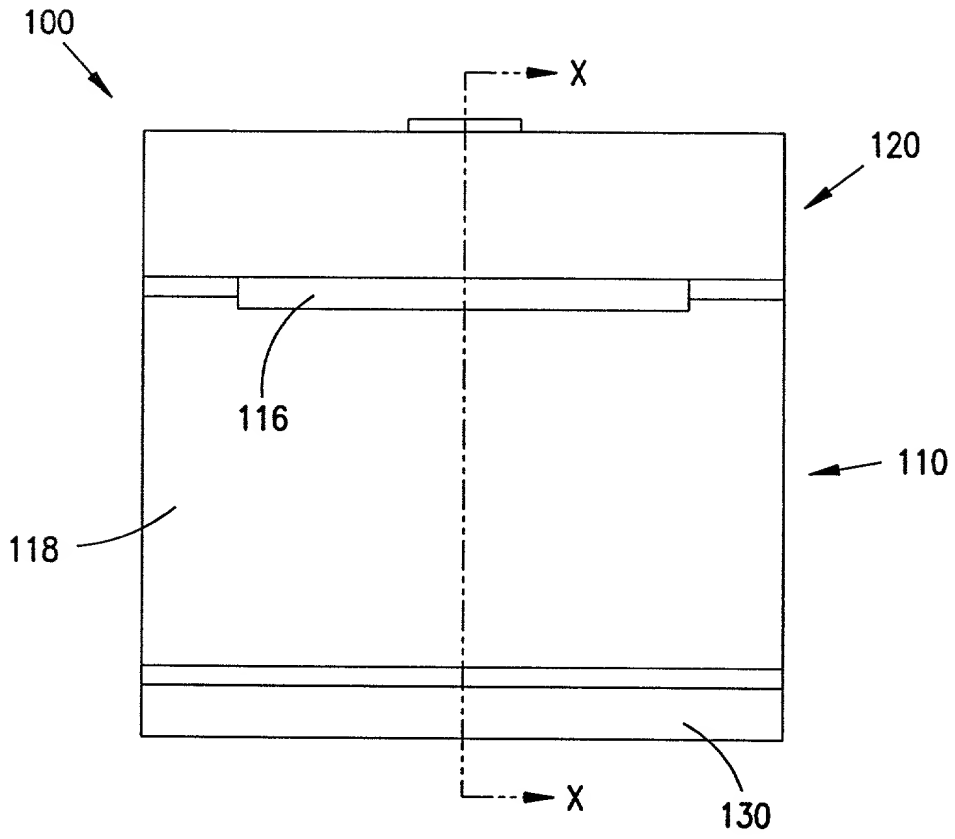
100
X
120
116
110
118
X
130

FIG. 4

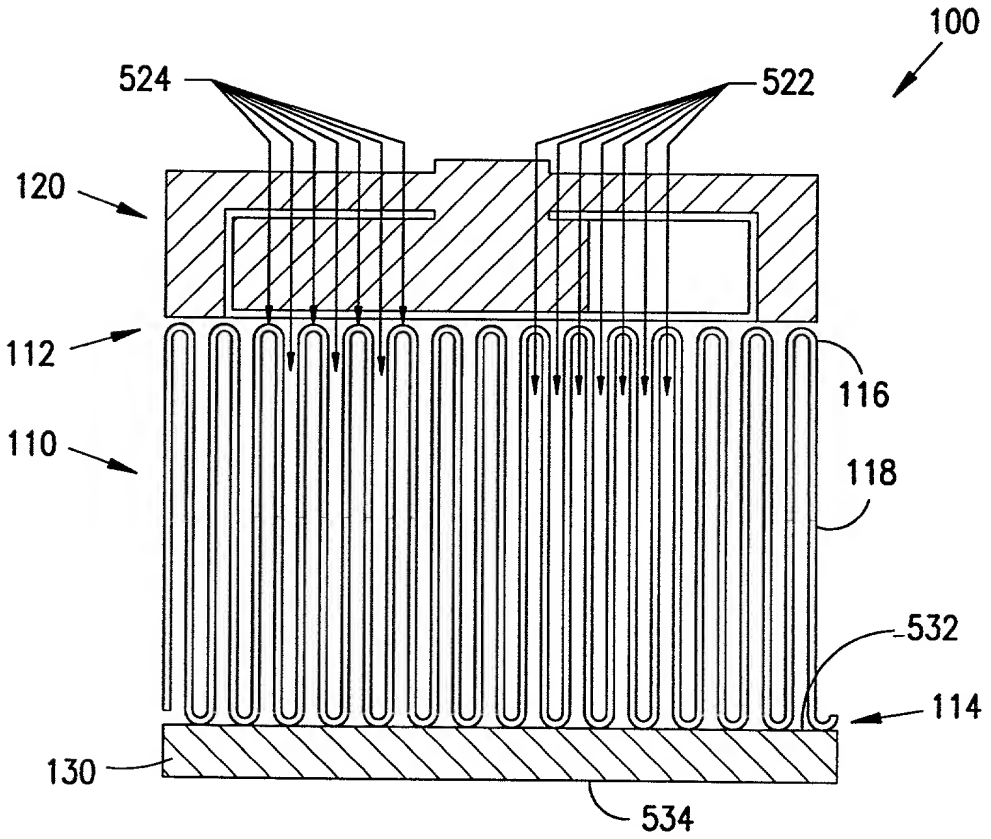
100
524
522
120
112
116
110
118
532
114
130
534

FIG. 5

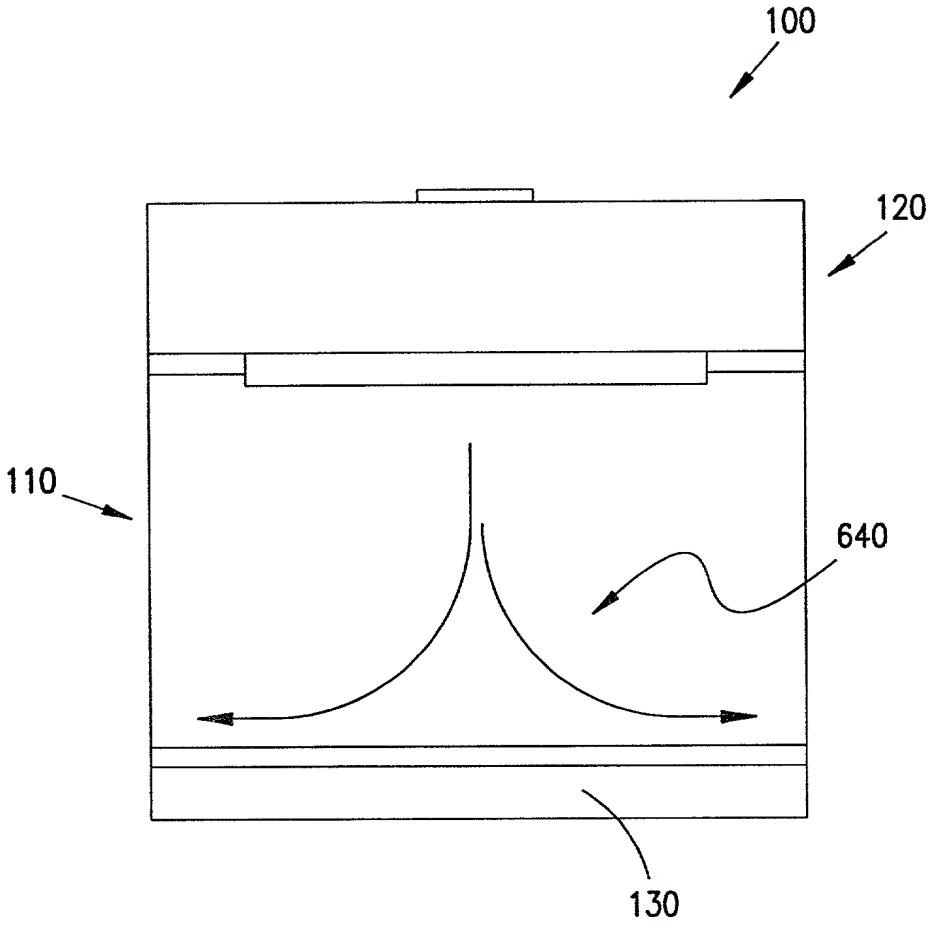

FIG. 6

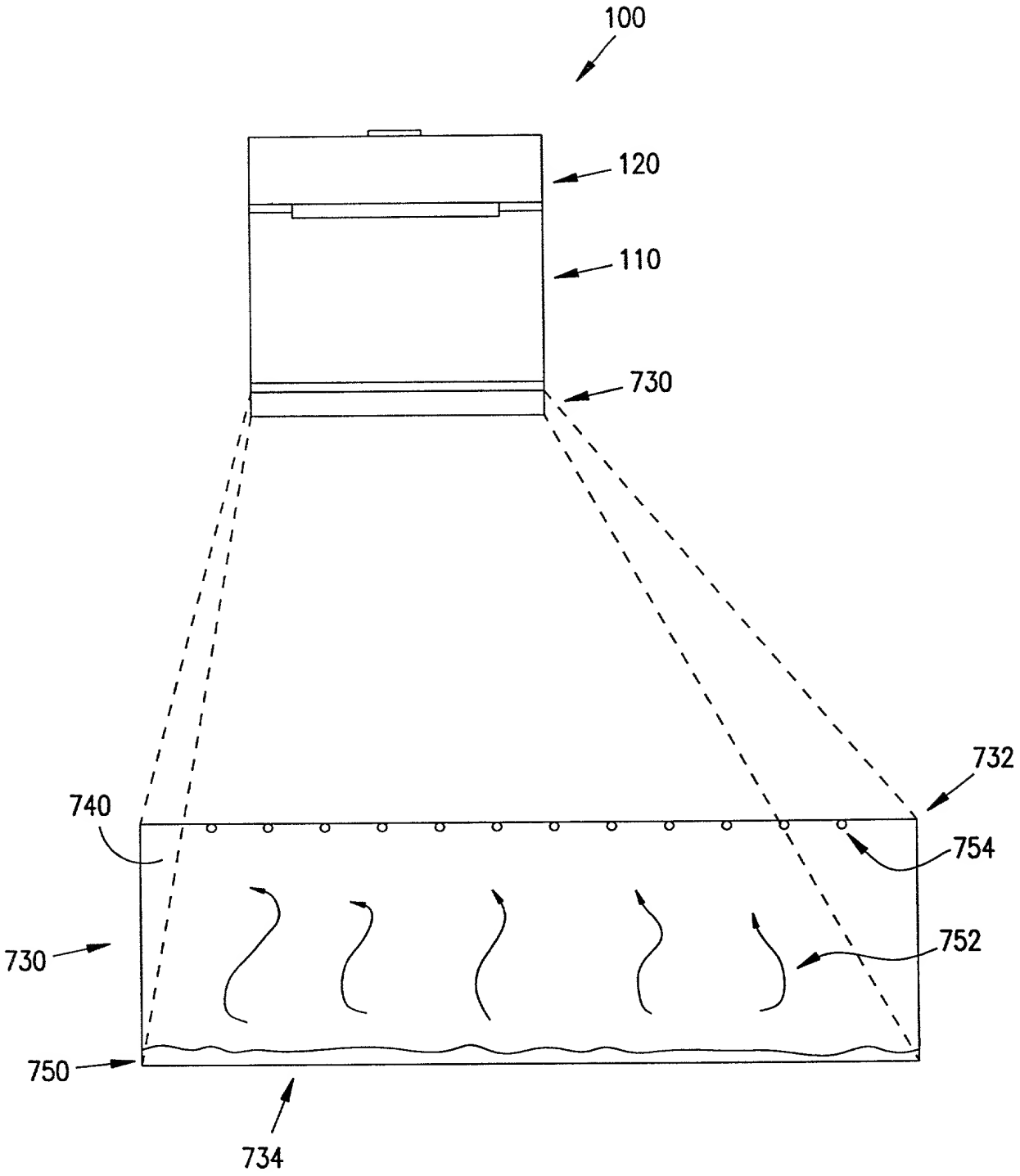

FIG. 7

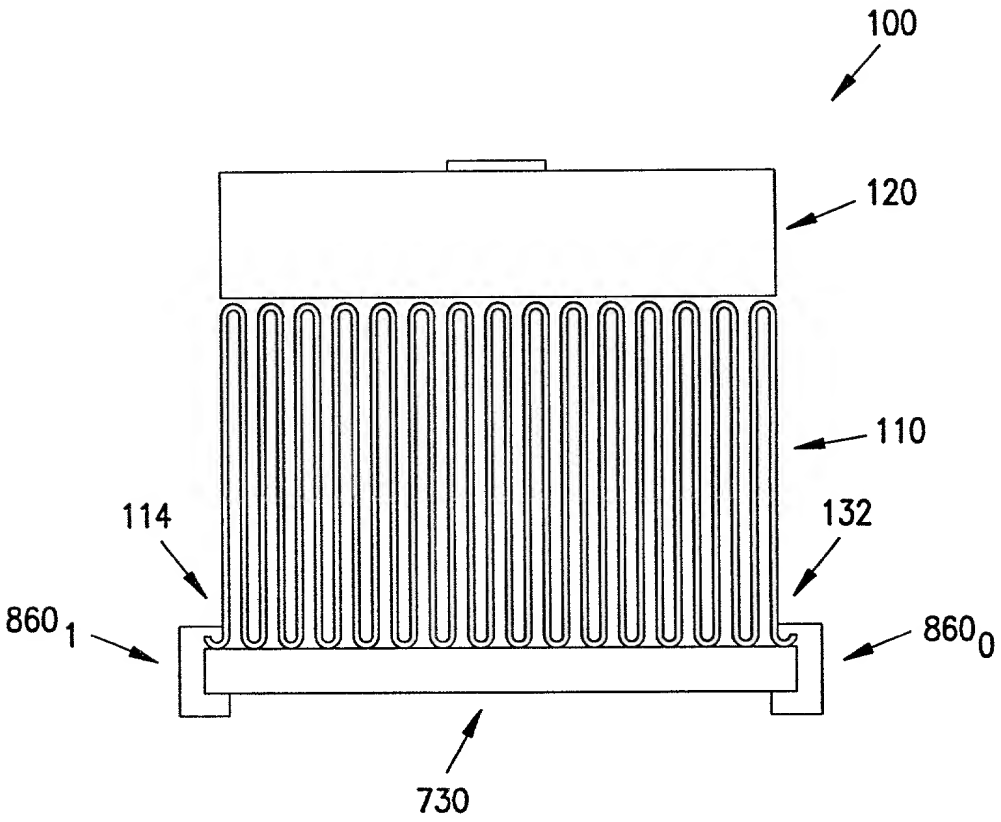

FIG. 8

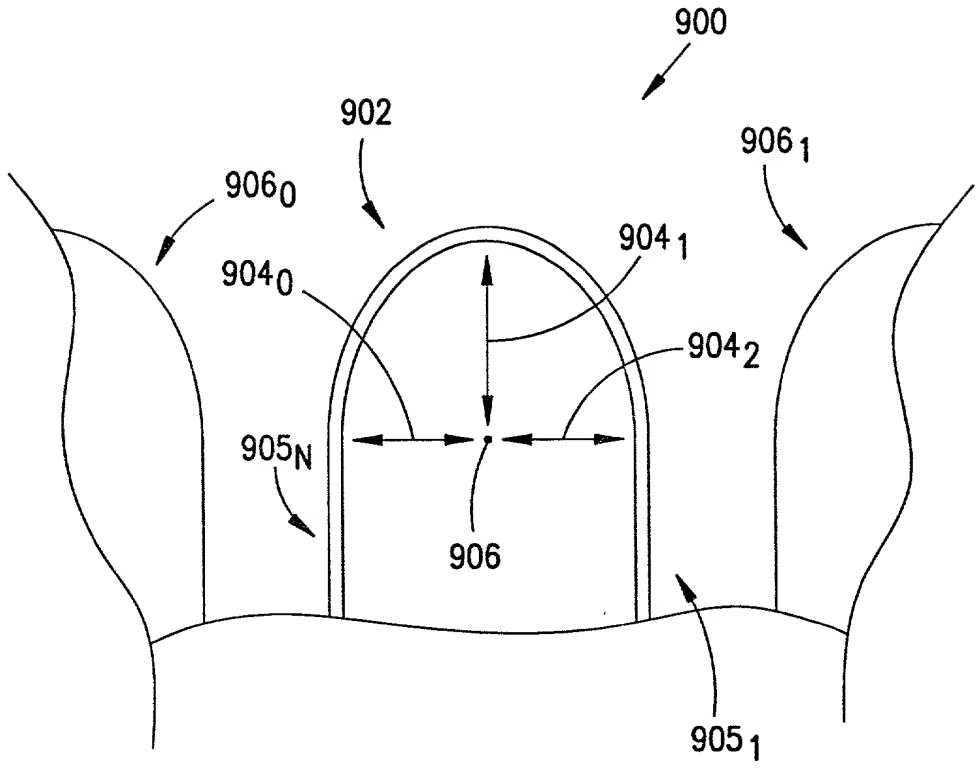

FIG. 9

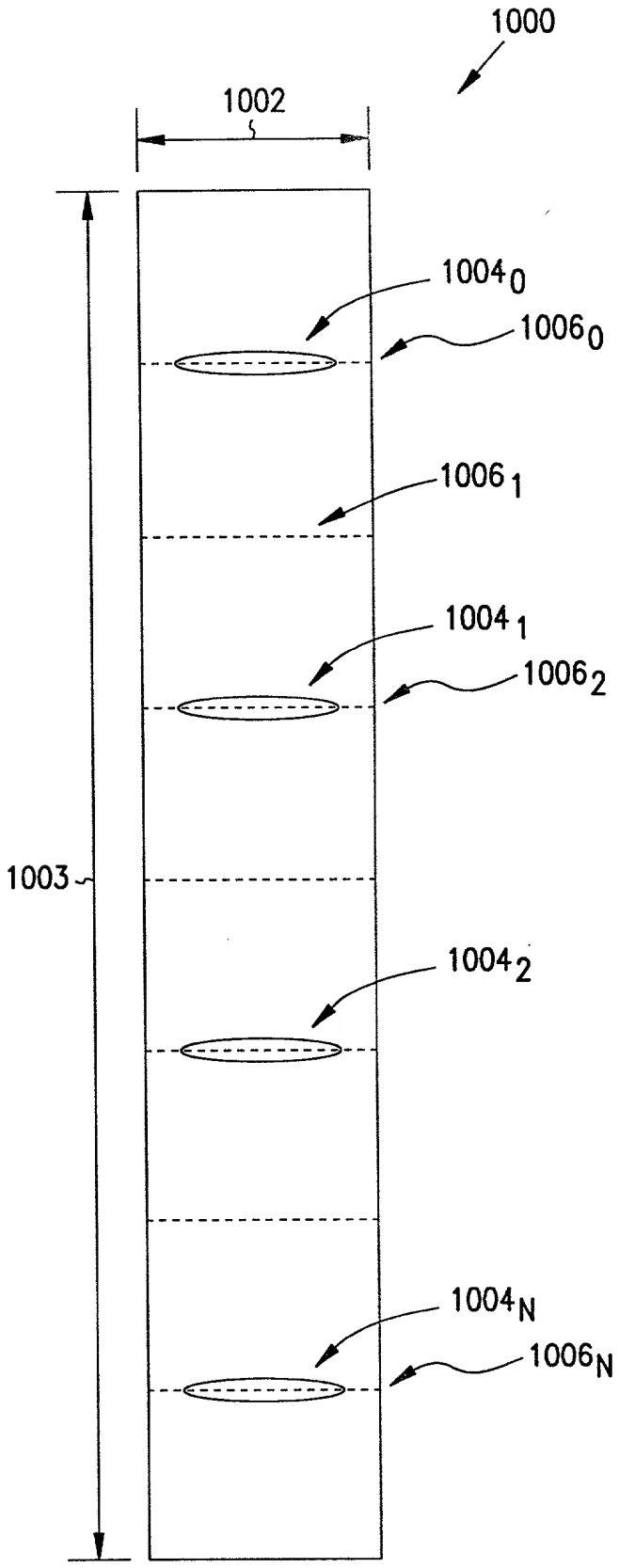
1000
1002
1003
1004_0
1006_0
1006_1
1004_1
1006_2
1004_2
1004_N
1006_N

FIG. 10

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **FOLDED FIN HEAT SINKS**.

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. § 1.56 (attached hereto). I also acknowledge my duty to disclose all information known to be material to patentability which became available between a filing date of a prior application and the national or PCT international filing date in the event this is a Continuation-In-Part application in accordance with 37 C.F.R. §1.63(e).

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 120 or 365(c) of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

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I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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Brooks, Edward J., III	Reg. No. 40,925	Lacy, Rodney L.	Reg. No. 41,136	Prout, William F.	Reg. No. 33,995
Chu, Dinh C.P.	Reg. No. 41,676	Leffert, Thomas W.	Reg. No. 40,697	Schwegman, Micheal L.	Reg. No. 25,816
Clark, Barbara J.	Reg. No. 38,107	Lemaire, Charles A.	Reg. No. 36,198	Sieffert, Kent J.	Reg. No. 41,312
Dahl, John M.	Reg. No. P-44,639	Litman, Mark A.	Reg. No. 26,390	Slifer, Russell D.	Reg. No. 39,838
Drake, Eduardo E.	Reg. No. 40,594	Lundberg, Steven W.	Reg. No. 30,568	Steffey, Charles E.	Reg. No. 25,179
Eliseeva, Maria M.	Reg. No. 43,328	Mack, Lisa K.	Reg. No. 42,825	Terry, Kathleen R.	Reg. No. 31,884
Embretson, Janet E.	Reg. No. 39,665	Maki, Peter C.	Reg. No. 42,832	Viksnins, Ann S.	Reg. No. 37,748
Fogg, David N.	Reg. No. 35,138	Malen, Peter L.	Reg. No. P-44,894	Woessner, Warren D.	Reg. No. 30,440
Fordenbacher, Paul J.	Reg. No. 42,546	Mates, Robert E.	Reg. No. 35,271		

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Schwegman, Lundberg, Woessner & Kluth, P.A. to the contrary.

Please direct all correspondence in this case to **Schwegman, Lundberg, Woessner & Kluth, P.A.** at the address indicated below:

P.O. Box 2938, Minneapolis, MN 55402
Telephone No. (612)373-6900

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of joint inventor number 1 : **Gregory M. Chrysler**
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Signature: Gregory M. Chrysler Date: 16 Aug '99
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Signature: L. J. Goodman Date: 16 AUG 1999
L. J. Goodman

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.